I/O Module

Table of Contents

1 Introduction 1
1.1 Ordering codes 2
1.2 Hardware Features 2
1.2.1 Connectors 3

2 Usage 5
2.1 Connecting External Signals 5
2.1.1 Input Signal Adaptation 5
2.1.2 Power Measurement 5
2.1.3 Power Probe 6
2.2 Configuration 10
2.2.1 Inputs 11
2.2.2 Outputs 11
2.2.3 Pattern OUT 11
2.3 Monitoring Inputs and Manipulating Outputs 13
2.3.1 Manipulation Dialog 13
2.3.2 HIL Monitor Plugin 14
2.3.3 Evaluation Expressions 14
2.3.4 Trace 15
2.3.5 Profiler 17
2.3.6 testIDEA 18
2.3.7 isystem.connect access 19

3 Output Pattern Generator 20
3.1 Pattern Definition File Format Specification 21

1 Introduction

The I/O Module is an optional add-on to the iC5000 emulator.

It provides the capability to measure digital and analog signals as well as drive them.

Input signals can be read out asynchronously from winIDEA IDE or by external applications and scripts using the ***isystem.connect*** interface. A real-time capture, alongside the on-chip trace or standalone, is also possible.

Output signals can likewise be driven from the IDE or via ***isystem.connect***. Beside simple assertion of an output, one or more outputs can be driven by a state machine based waveform generator, which can be triggered by input signals.

testIDEA uses ***isystem.connect*** interface to assert outputs prior to the test and verify inputs after the test.

1.1 Ordering codes

iSYSTEM offers two I/O Modules featuring different sets of ports. Refer to the chart below for more information about the differences between the modules.

- **IC50011** (Standard I/O Module – IOM2),
- **IC50014** (24-port digital I/O Module – IOM2-D)

1.2 Hardware Features

Feature	IOM2	IOM2-D
System Port: inter-emulator synchronization and trigger output, 100ohm series termination	Yes	Yes
Digital inputs: 10kOhm input impedance, 5V tolerant, ESD protected	8	24
Digital outputs: 100ohm output series termination, ESD protected	8	8
Analog inputs: 8-bit ADCs, 1MSPS, 1MOhm input impedance, range is ±5.0V with 1:1 probe, ±50V with a 10:1 probe, 3ns acquisition time. Power measurement probe uses these two inputs for power measurement.	2	
Analog outputs: 8-bit DACs, ±4.5V bipolar output, ±7mA drive, 100ohm output resistance	2	2
Current Sense Port: For power measurement via Power Probe	Yes	
10MHz temperature compensated precision oscillator TCXO for a high accuracy long duration trace/analyzer session measurements	Option	Option

All digital signals are 3.3V LVTTL compatible and are ESD protected.

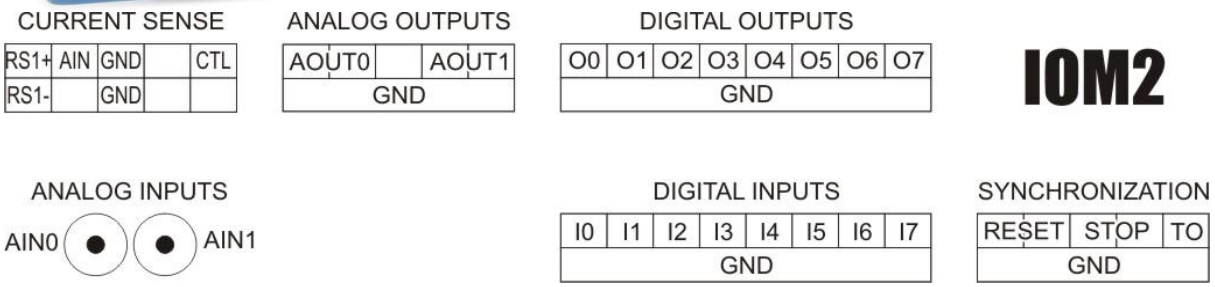
All analog signals have a Schottky diode over- / undervoltage protection, except the Current Sense signals.

The maximum voltage on the Current Sense probe is 60V.

Nominal sampling rate of all inputs and outputs is 1MSPS.

1.2.1 Connectors

1.2.1.1 IOM2



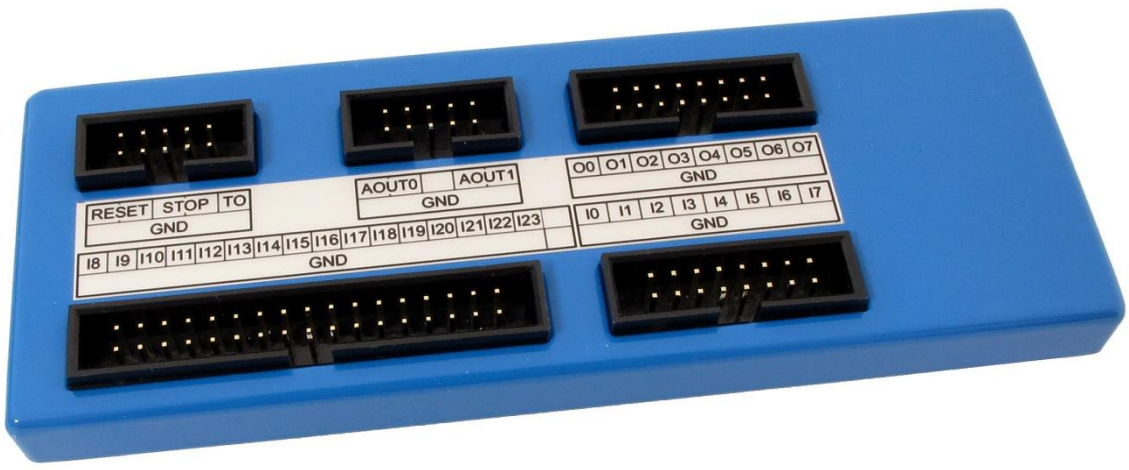
Connector Pinout

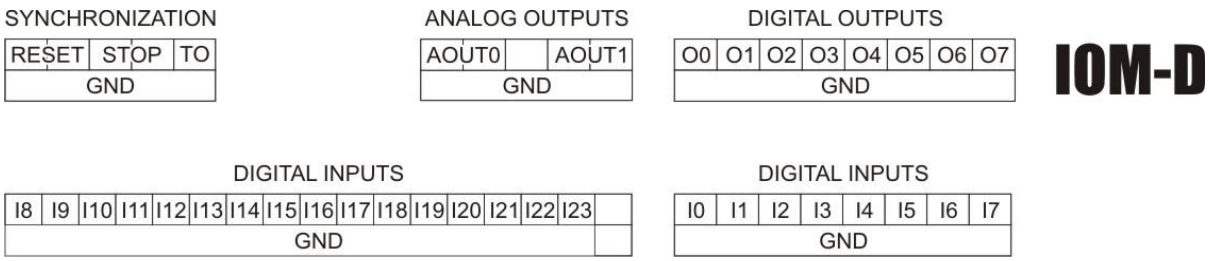
- 10-pin header for the System Port.
- 16-pin header for 8 digital inputs.
- 16-pin header for 8 digital outputs.
- 10-pin header for 2 analog outputs.
- 2 BNC connectors for 2 analog inputs.
- 10-pin header for Power Measurement Port (rev. C and later).

All connectors, except the BNCs, are standard Berg 2.54mm / 100mils raster.

For analog inputs, standard scope probes can be used.

1.2.1.2 IOM2-D


RESET STOP TO
GND
AOUT0 AOUT1
GND
O0 O1 O2 O3 O4 O5 O6 O7
GND
I0 I1 I2 I3 I4 I5 I6 I7
GND
I8 I9 I10 I11 I12 I13 I14 I15 I16 I17 I18 I19 I20 I21 I22 I23
GND



- 10-pin header for the System Port.
- 16-pin header for 8 digital inputs.
- 32-pin header for 16 digital inputs.
- 16-pin header for 8 digital outputs.
- 10-pin header for 2 analog outputs.

All connectors are standard Berg 2.54mm / 100mils raster.

2 Usage

2.1 Connecting External Signals

2.1.1 Input Signal Adaptation

When connecting to external signals please make sure not to exceed the specified input and output range of the IOM signal interface. If the digital input source voltage is higher than 5V, please condition the signal source with a suitable resistor divider, or a resistor-zener diode limiter.

In case, for example, a 24V source is connected directly to a module digital input, an excess input current of about 18mA will flow through an input 1K resistor and a diode in the ESD protection device to the module internal 5V power supply.

Although this may not sound catastrophic, it must be avoided. Any long-term exposure will lead to a degradation of the module electronics due to electromigration.

On the other hand, if an analog input signal amplitude is smaller than the module input analog range, it is recommended to add a suitable amplifier to make use of the full A/D converter resolution.

2.1.2 Power Measurement

When the IOM is switched to Power Measurement mode (***Hardware/Options/ IO*** dialog, ***Use AIN0/AIN1 for Power Measurement***), the **AIN0** is used for voltage measurement and **AIN1** for current measurement.

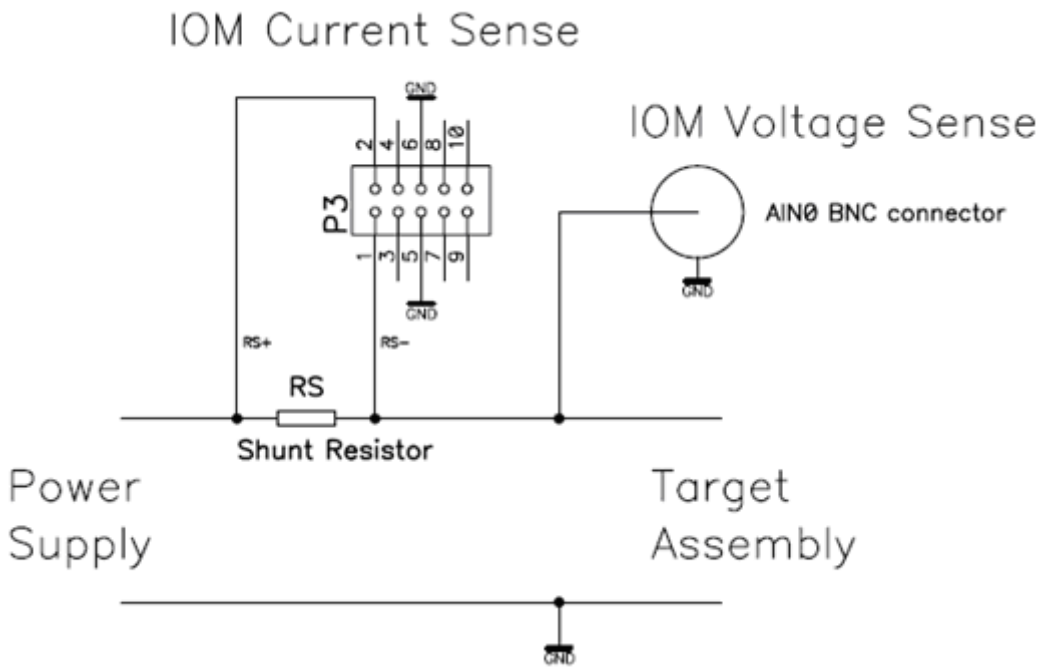
For voltage measurement

- Connect **AIN0** input to the target voltage at the **RS-**. That's the low side of the target shunt resistor.
- If the voltage is higher than 5V, use a suitable resistor divider. Enter the divider ratio as a ***Voltage/Multiply*** factor in the configuration dialog.

For current measurement

- Disconnect the **AIN1** from other sources
- Use the **Current Sense** connector to connect the **RS+** and **RS-** pins to a high side and a low side of the target shunt resistor, respectively.
- Specify the resistance of the **RS** shunt resistor in the configuration dialog.

This schematic depicts correct power measurement setup.

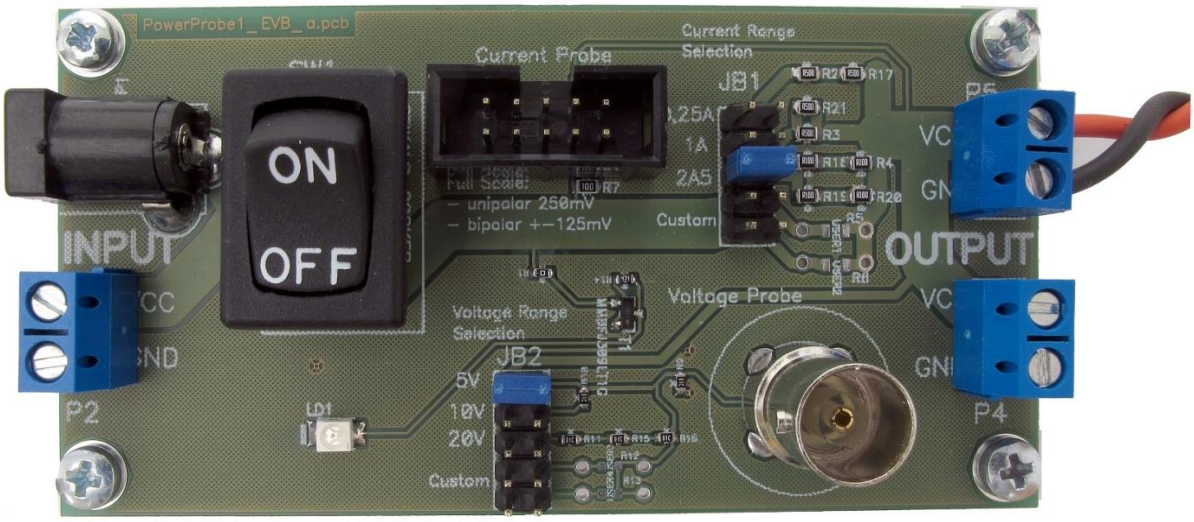


Note: The full-scale shunt voltage range is 250mV. So, for example, a 1Ω shunt resistor gives a current range of 250mA.

Full-scale Shunt Voltage	Shunt Resistance	Full-scale Current Range	Shunt Power Dissipation
250mV	1.00 Ω	0.25A	0.063W
250mV	0.25 Ω	1.00A	0.250W
250mV	0.10 Ω	2.50A	0.625W

2.1.3 Power Probe

The ***PowerProbe*** is an optional power interface board. It is to be connected between a target power supply and a target board itself. Additional connections are to be made for the IOM current and voltage probes.



2.1.3.1 Connectors, Jumpers and a Switch

P1 and P2

Target power supply inputs. Use one or the other. Maximum voltage is 20V.

P3

10-pin Berg connector to connect the IOM **Current Probe**.

P4 and P5

Power supply output towards the target.

ST1

BNC connector for the IOM Voltage Probe. To be connected to the **AIN0** analog input.

JB1

Jumper block for selecting different shunt resistors.

Note:
1) Excessive current will burn the resistors.
2) Never set more than one jumper position at a time.
3) Selected shunt resistors must handle the heat generated by the power dissipated on them.

Three of the five available positions are populated with resistors:

Position	Shunt Resistance	Shunt Resistance including JB1
0.25A	1.00 Ω	1.00 Ω
1A	0.25 Ω	0.26 Ω
2A5	0.10 Ω	0.11 Ω

The remaining two positions are available for a custom user setup with unpopulated resistors R5 and R6.

Note that with lower shunt resistor values also the JB1 jumper resistance starts to play a role and may influence the measurement. This can be easily compensated by slightly increasing the shunt resistance value in the winIDEA setup dialog, by 0.01Ω, for example.

JB2

Jumper block for selecting different voltage ranges.

Note: 1) Never set more than one jumper position at a time.

Three of the five available positions are populated with resistor dividers:

Position	Resistors	Voltage Multiply (configuration)
5V	0/10kΩ	1
10V	10/10kΩ	2
20V	30/10kΩ	4

The remaining two positions are available for a custom user setup with unpopulated resistors **R12** and **R13**. The lower part of the voltage divider is set by the **R9** of 10kΩ.

SW1

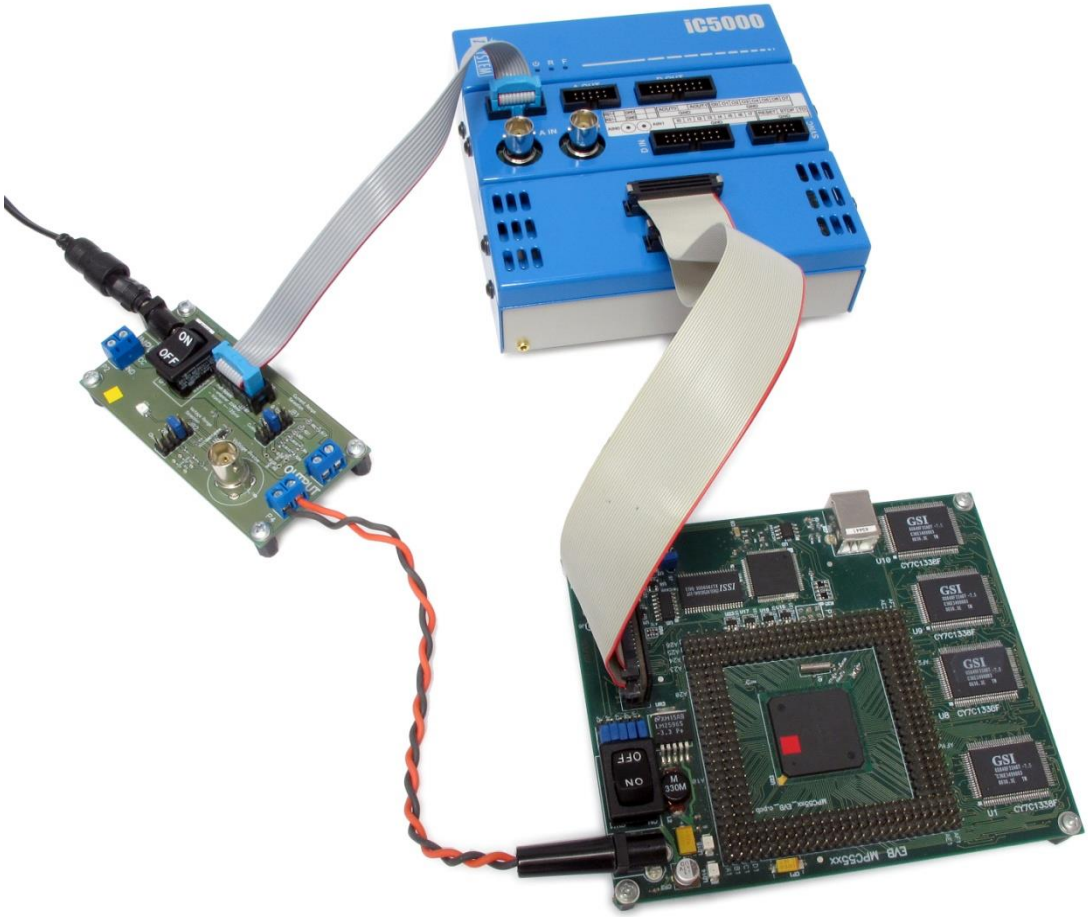
Switches target power on or off.

LD1

Power LED. Note that the LED needs a very small current to light and may glow because of a parasitic current flowing, for example, when the emulator switched on and the target is off.

2.1.3.2 Connection Procedure

- Switch off target and emulator
- Power down the target supply
- Select 2.5A or higher target current range to be on the safe side
- Select 20V voltage range
- Set SW1 to OFF position
- Connect target supply to P1 or P2
- Connect target to P4 or P5
- Connect the ST1 voltage probe to the IOM AIN0 input
- Connect P3 to the IOM Current Sense connector
- Switch emulator on
- Switch target supply on
- Switch SW1 to ON position
- Now, you are set to go.



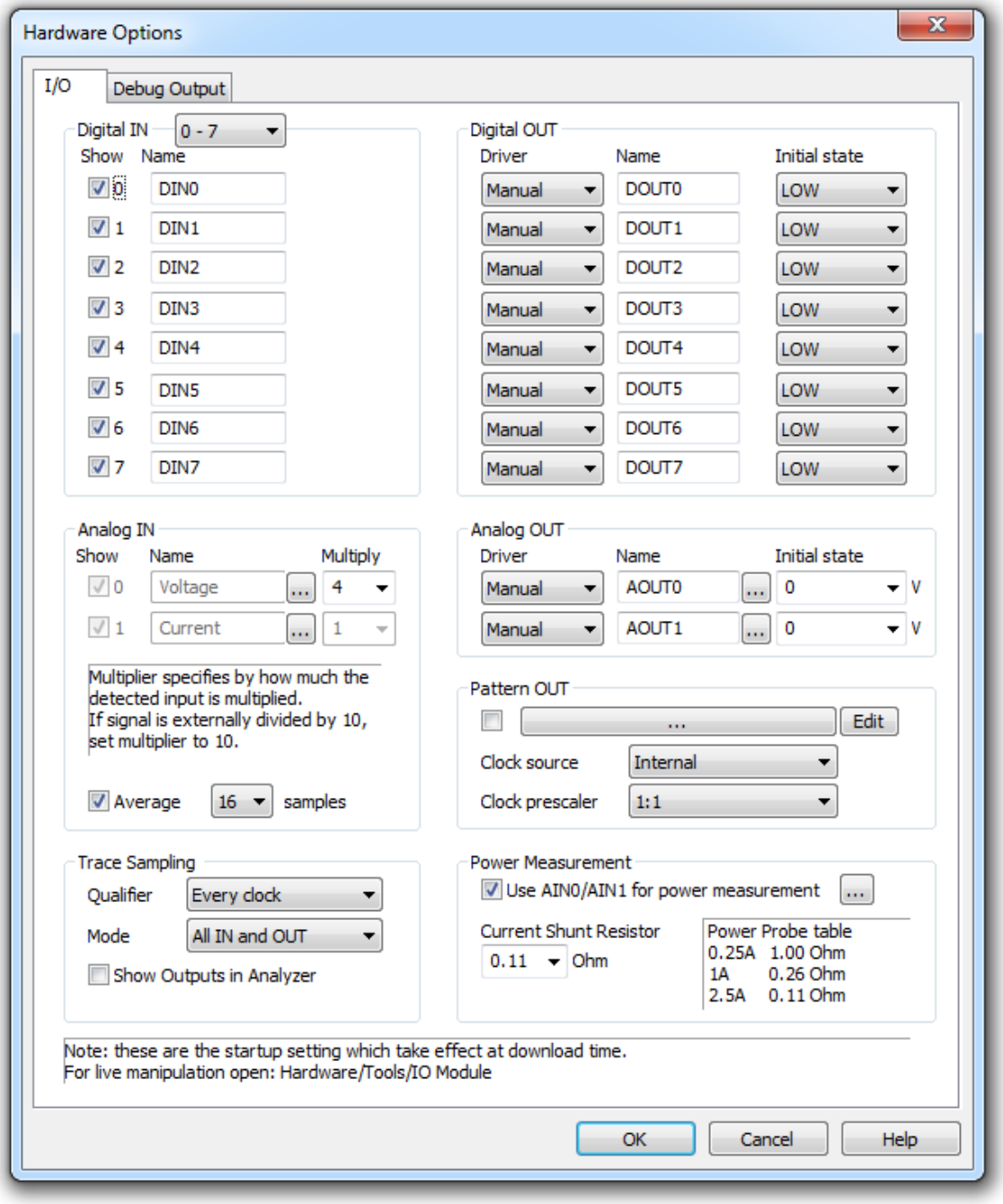
In case the target current and/or voltage are below the other given ranges, repeat the procedure above and select appropriate ranges to improve resolution of the measurement.

2.1.3.3 Verification

To verify that the displayed voltage and current values are correct, use an independent voltage and current measurement instrument.

2.2 Configuration

I/O module configuration is performed in ***Hardware/Options*** dialog.



All signals are accessible (HIL interface) by a configurable symbolic name. I/Os are mapped as follows:

I/O	HIL Mapping	Example
Digital IN	DigitalIn.<*name*>	DigitalIn.DIN0
Digital OUT	DigitalOut.<*name*>	DigitalOut.MyOutput
Analog IN	AnalogIn.<*name*>	AnalogIn.Temperature

Analog OUT	AnalogOut.<*name*>	AnalogOut.AOUT1

2.2.1 Inputs

Show

If set, the Input will be shown in the Measurment plugin and via HIL interface.

2.2.1.1 Analog IN

Multiply

Multiplier specifies by how much the detected input is multiplied.

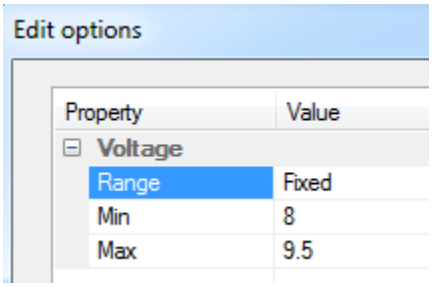
If a signal is externally divided by 10, set the multiplier to 10.

Advanced configuration

The … button next to signal name allows further configuration of an analog signal.

Range setting provides means to display an analog signal scaled to the range of interest.

- ***Full*** the signal is scaled between minimum and maximum measurable range
- ***Fixed*** the signal is scaled between the configured ***Min*** and ***Max*** values
- ***Auto*** the signal is scaled between minimum and maximum recorded values



2.2.2 Outputs

Driver

An output can be driven manually (e.g. via script or Manipulation Dialog), via Pattern engine or both.

Driver	Effect
Disabled	The output cannot be driven
Manual	The output can be driven manually only
Pattern	The output can be driven by the pattern engine only
Both	The output can be driven manually and by the pattern engine

Initial state

When the I/O module is initialized, the outputs will assume the specified initial state.

2.2.3 Pattern OUT

Outputs can be driven by the Pattern engine (see Output Pattern Generator). This setting defines which Pattern program is loaded at initialization time.

Clock Source

This is the pattern clock source.

- Internal – the 1MHz internal sampling clock is used (default)
- External – the positive edge on DIN0 is used as clock

Clock Prescaler

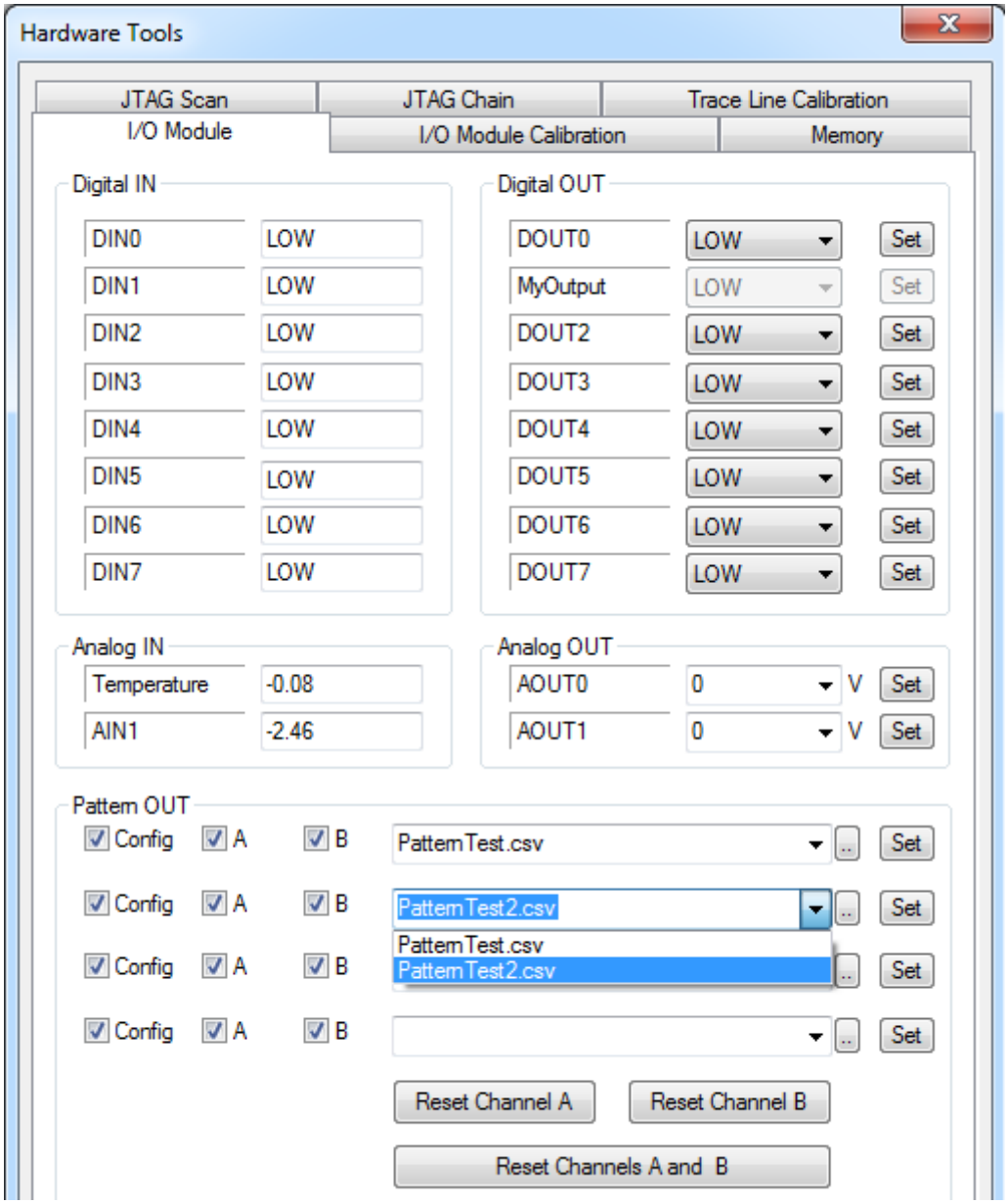
Prescaler is used with in conjuction with the pattern sample duration.

This setting is used only with internal ***Clock Source.*** The 1:1 prescaler is using the internal 1MHz clock.Using higher prescalers, longer durations can be achieved.

2.3 Monitoring Inputs and Manipulating Outputs

2.3.1 Manipulation Dialog

The ***Hardware/Tools/IO Module*** dialog provides the monitoring and manipulation capability of the I/O Module.



2.3.1.1 Inputs

For all inputs the currently detected state is displayed and periodically refreshed.

2.3.1.2 Outputs

Digital and Analog outputs which can be ***manually*** driven, can be asserted to the specified value.

Note: the value is asserted when the ***Set*** button is clicked.

2.3.1.3 Pattern OUT

New Pattern programs can be loaded with the ***Set*** button.

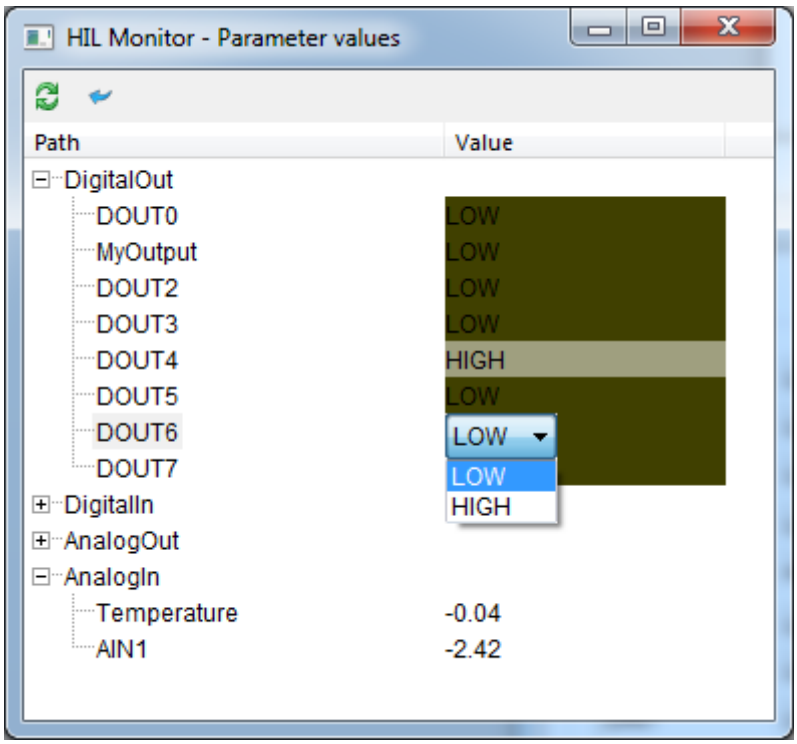
The ***Config***, ***A*** and ***B*** options specify which part of the program is loaded from the pattern file:

- Config – pattern state machine configuration is loaded
- A – table A is loaded
- B – table B is loaded

Reset Channel buttons can reset individual or both channels of the pattern engine (HRPTABx input is driven active)

2.3.2 HIL Monitor Plugin

Plugin/HIL Monitor provides the monitoring and manipulation capability of the I/O Module.



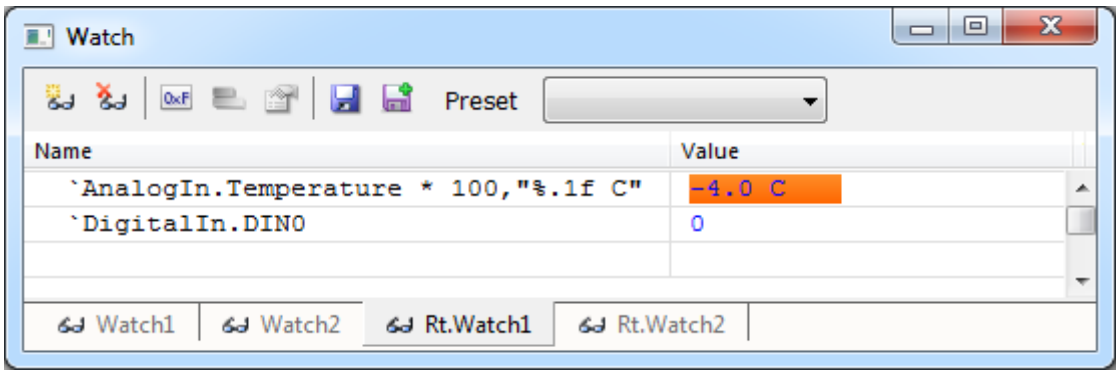
To modify an output, double click its value in the ***Value*** column.

To refresh the inputs manually, click the icon.

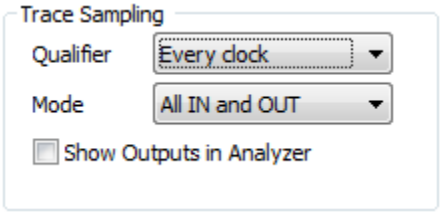
To refresh the inputs manually, click the icon.

2.3.3 Evaluation Expressions

HIL variables can be used in standard expressions, by using the apostrophe ` prefix.



2.3.4 Trace



All Input signals are sampled simultaneously. The sampling is configured in the ***Hardware/Options*** dialog.

Qualifier

Qualifier defines an additional filter for sampling.

- Every clock – a sample is taken at every 1MHz internal clock
- Every 4 / 16 / 64 clocks – a sample is taken at a divided rate
- On change – a sample is taken only when the states on the input lines change. This reduces the amount of recorded data.

Note: only input lines which are not *disabled* in the ***Hardware/Options*** dialog are monitored for change.

Mode

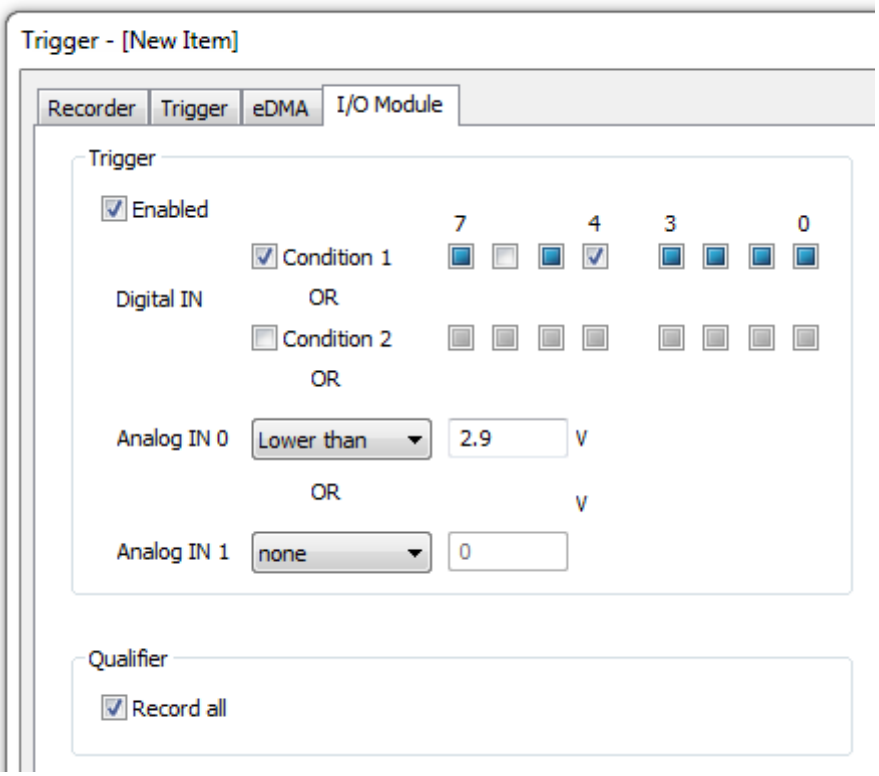
- All IN and OUT – all input and output lines are sampled
- Direct DIN0-3 – digital inputs 0-3 are sampled at 10MHz rate. ***On change*** qualifier is used in this case. Note that other inputs and outputs are not operational in this mode.

Show Outputs in Analyzer

If this option is checked, the outputs will be shown in the Analyzer Timeline.

2.3.4.1 Trigger configuration

The I/O module can generate a trigger for the iC5000 trace engine. Configuration is available in the trigger configuration dialog of the Analyzer window.



2.3.4.1.1 Trigger

Trigger determines the condition upon which the I/O module will signal the iC5000 to start recording.

Enabled

Enables the I/O module trigger output to the iC5000 trace engine.

Digital IN

Digital inputs 0 – 7 can be a trigger source. Two combinations of digital inputs (Condition 1 and Condition 2) can be defined.

- ☐ trigger if this input is in low state
- ☑ trigger if this input is in high state
- ■ do not consider this input in the trigger condition

A condition is fulfilled if the enabled inputs match the configured value.

The trigger will be generated if either of enabled Conditions matches.

In the above example, trigger is generated if DIN4 is high and DIN6 is low, or AIN0 is below 2.9V.

Analog IN 0 and 1

Both analog inputs can be a trigger source. The trigger is generated if the measured voltage is ***Low***er or ***High***er than the specified threshold.

2.3.4.1.2 Qualifier

Qualifier determines the type of I/O module acquired information which is recorded in the trace buffer and streamed to the host.

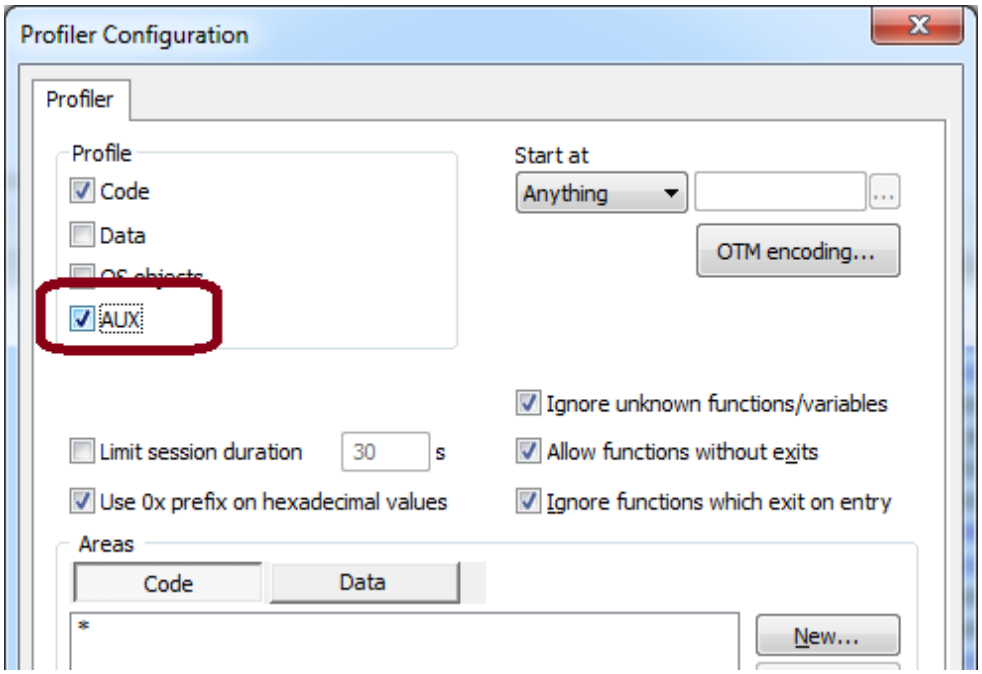
Record all

If this option is checked then all I/O module inputs are recorded. Otherwise no I/O samples are recorded.

2.3.5 Profiler

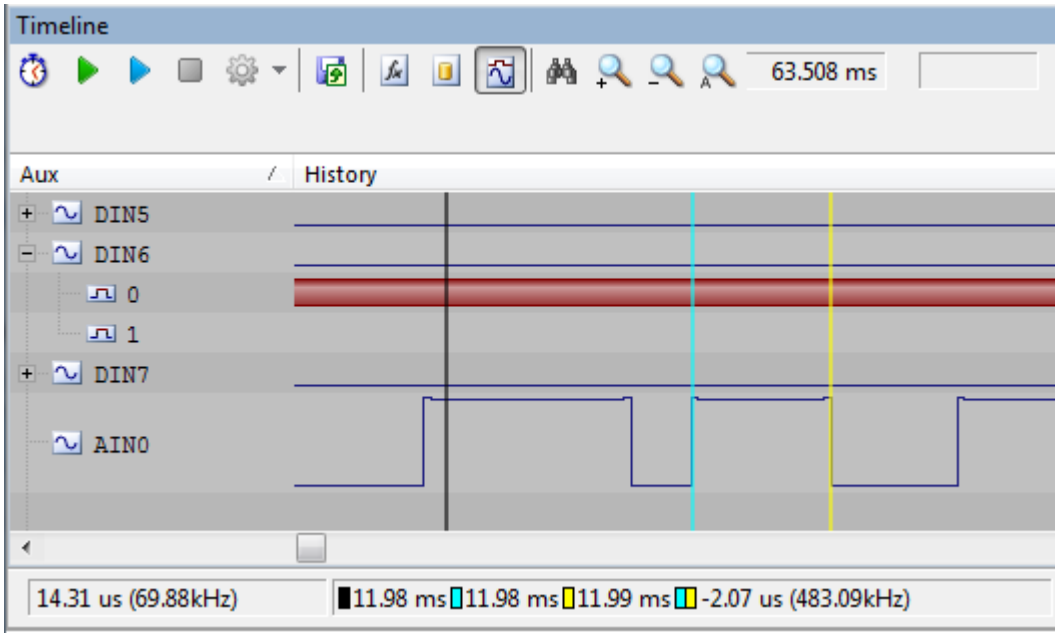
Real-time profiling of I/O module's signals is available in Analyzer's Profiler mode.

To enable profiling, enable the ***AUX*** option in the ***Profiler configuration*** dialog.



Both inputs and outputs are traced and displayed in the timeline view.

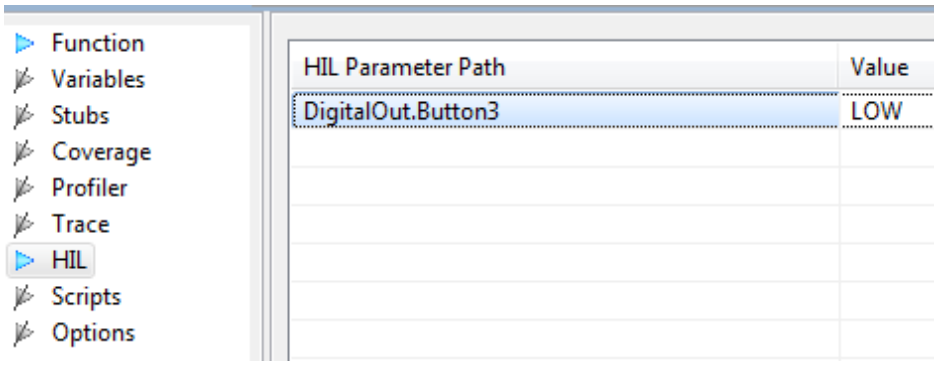
Digital lines are treated as ***state*** variables, Analog lines as ***regular*** variables.



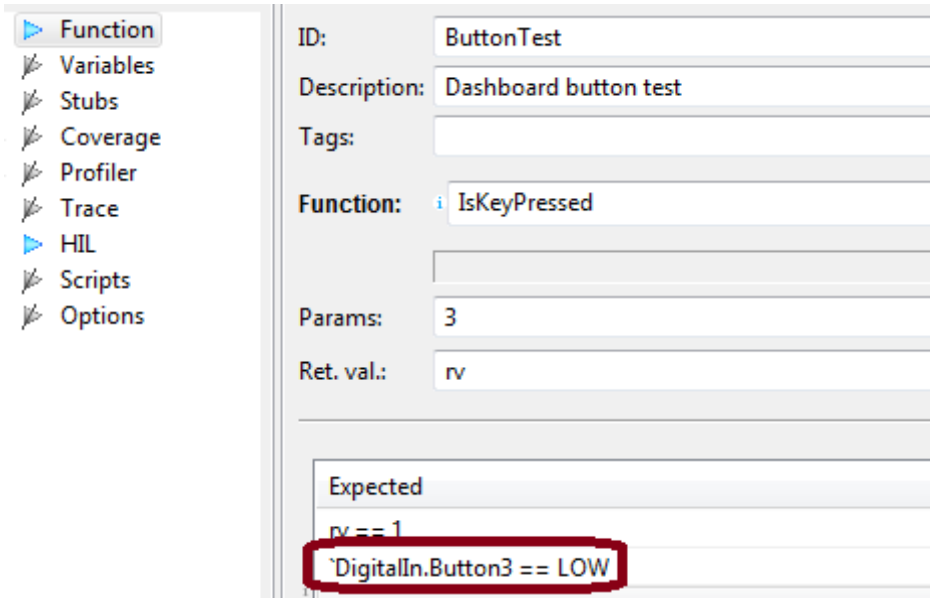
For more information refer to the ***Analyzer*** document.

2.3.6 testIDEA

testIDEA is using the HIL interface to gain access to the I/O Module. This allows setting of inputs prior to performing a unit test:



…and evaluation of outputs after the test:



For more information please refer to testIDEA manual.

2.3.7 isystem.connect access

External applications can use isystem.connect to monitor and manipulate the I/O module via the HIL interface class ***CHILController***.

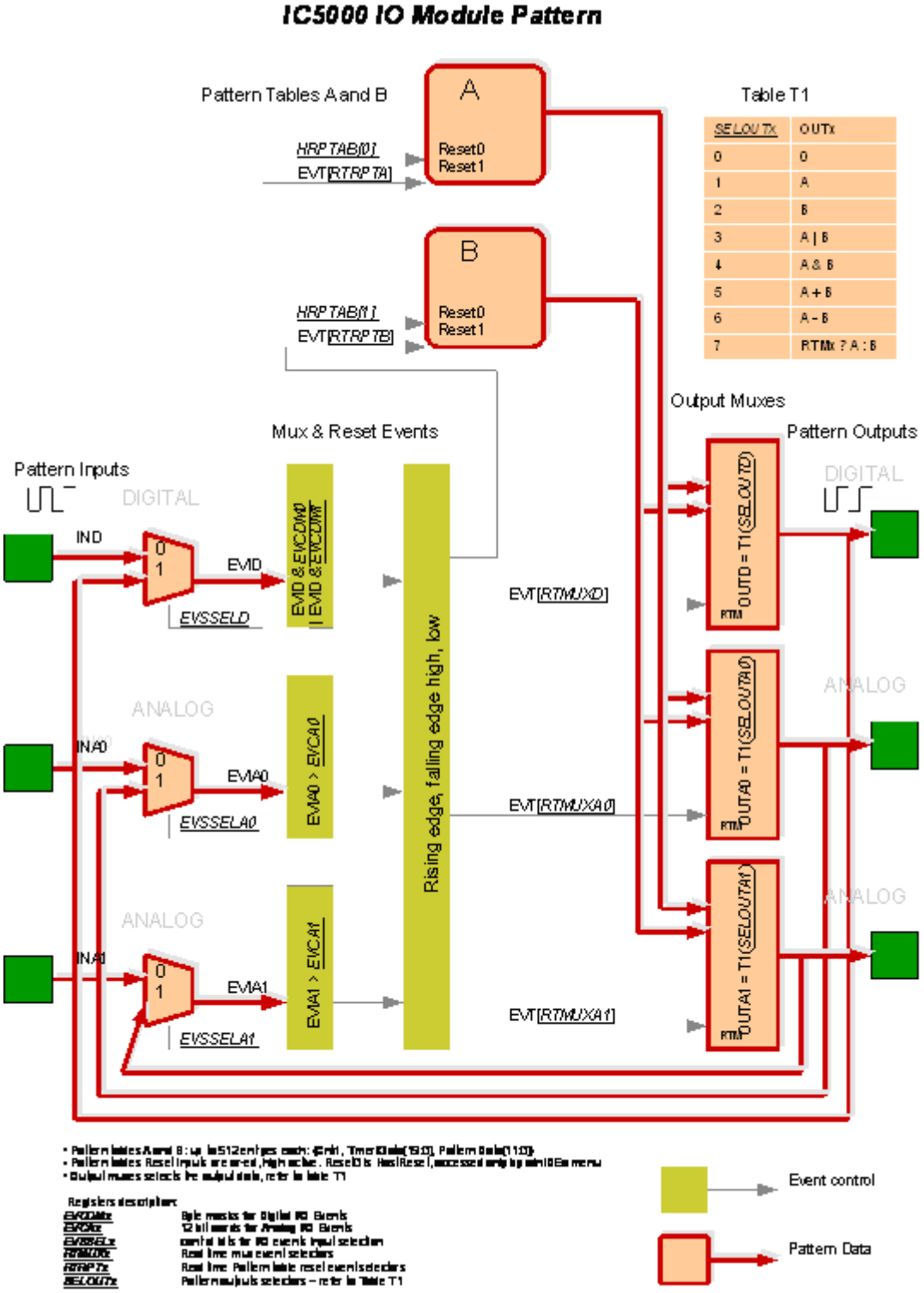
This Python example demonstrate s reading and writing analog and digital I/Os.

```
import isystem.connect as ic

#create connection and hil controller object
cMgr = ic.ConnectionMgr()
cMgr.connectMRU('')

hilCtrl = ic.CHILController(cMgr)

#set analog output to specified voltage level
def AnalogOutputWrite(channelName, voltageLevel):
  hilCtrl.write('AnalogOut.' + channelName + ': ' + voltageLevel)

#get analog input voltage level
def AnalogInputRead(channelName):
  return hilCtrl.read('AnalogIn.' + channelName)

#set digital output to specified level
def DigitalOutputWrite(channelName, state):
  hilCtrl.write('DigitalOut.' + channelName + ': ' + state)

#get digital input state
def DigitalInputRead(channelName):
  return hilCtrl.read('DigitalIn.' + channelName)



AnalogOutputWrite('AOUT0', '1.8')
print "Analog input AIN0 voltage level: ", AnalogInputRead('AIN0')

DigitalOutputWrite('DOUT0', 'HIGH')
print "Digital input DIN0 state: ", DigitalInputRead('DIN0')
```

3 Output Pattern Generator

The Pattern module generates data on 3 output ports, one 8-bit digital and two analog.

The output data is selected by individual Output Muxes and provided by Pattern Tables A an B. Table T1 shows all possible options available. Registers ***SELOUTD***, ***SELOUTA0*** and ***SELOUTA1*** select options, as defined in the Table T1. Option #7 (RTMx ? A : B) provides the possibility to alter the pattern output data according to some real time events using RTM input of the Output Mux. When the RTM is high, the Table A is selected, and Table B otherwise.



The RTM inputs are selected by ***RTMUXD***, ***RTMUXA0*** and ***RTMUXA1*** registers and provided by Event Comparators. Low, High, Falling or Rising for each Digital, Analog0 and Analog1 comparators are available. The Digital Event Comparator compares input data selected by ***EVSSELD*** to ***EVCDM0*** and ***EVCDM1*** registers. Analog Comparators compare input data selected by ***EVSSELA0/1*** to ***EVCA0/1*** registers. ***EVSSELD/A0/A1*** registers chooses comparator inputs between IOModule input ports and Pattern Output ports.

Pattern Tables A and B can be reset in real time, using ***RTRPTA*** and ***RTRPTB*** registers, which choose the reset event. Pattern tables can be also reset by the host via ***Hardware Tools / I/O Module*** dialog.

Each of Pattern Tables A and B can hold up to 512 entries. Data size 12 bit. Time resolution 1us, data change can be delayed for 2^20 us max.

3.1 Pattern Definition File Format Specification

Pattern definition file is a CSV file using the following format.

```
HEADER,<version>  // must preceede any other entry other than REM
<version> = 1

REM[,comment]
```

Defines a comment.

```
CFG,<REGNAME>,<REGVALUE>
```

Configures a register.

```
<REGNAME>  = name of register
<REGVALUE> = 0x<hex> | <dec> | <enum> | <voltage in mV>
```

REGNAME	REGVALUE
SELOUTD SELOUTA0 SELOUTA1	0 A B A | B A & B A + B A - B RTMx ? A : B
RTRPTA RTRPTB RTMUXD RTMUXA0 RTMUXA1	0 DL DH DF DR A0L A0H A0F A0R A1L A1H A1F A1R
EVCDM0	0x<hex> | <dec>
EVCDM1	0x<hex> | <dec>
EVCA0	<voltage in mV>
EVCA1	<voltage in mV>
EVSSELD EVSSELA0 EVSSELA1	IN OUT

```
TABLE[, [A | B] [, mV]]
```

Defines a table. SEQ and GOTO entries which follow are put into this table.

if A or B is not specified, a non assigned table is loaded - used for incremental programming

if mV is specified, the data is interpreted as millivolts and is adjusted by the loader

```
SEQ, <duration>[, <data>[, <label>]]
```

Defines a single sequential table entry, its duration, data to assert on the output and a label.

```
<duration> = <dec> | <def>
<data>     = 0x<hex> | <dec> | <def>
```

```
GOTO, <destination>[, <data>]
```

Defines a jump in the table. The jump consumes one cycle, if data is specified, this data is asserted for the duration of the cycle.

```
<destination> = <label> | <dec> | 0x<hex>
<data>     = 0x<hex> | <dec> | <def>
```

```
DEF, <label>[, <value>]
```

Defines a label, if <value> is omitted, current position is used.

```
<value>     = 0x<hex> | <dec> | <label>
```

Example:

TableA square

```
HEADER, 1

CFG,SELOUTD,B
CFG,SELOUTA0,A
CFG,SELOUTA1,B

TABLE,A, mV
SEQ,194,-4000,L0
SEQ,195,+4000
GOTO,L0
```

Disclaimer: iSYSTEM assumes no responsibility for any errors which may appear in this document, reserves the right to change devices or specifications detailed herein at any time without notice, and does not make any commitment to update the information herein.

© iSYSTEM . All rights reserved.